REMEDIAL ACTION PLAN

800 WEST WYOMING AVENUE, LOCKLAND, OHIO

SME Project Number: 066744.00.004.002

April 30, 2015

PREPARED FOR: Village of Lockland, Ohio
COOPERATIVE AGREEMENT # BF-00E01049-0

SME

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April 30, 2015

Mr. David Krings
Village of Lockland
101 North Cooper Avenue
Lockland, Ohio 45215

RE: Remedial Action Plan
USEPA Assessment Grant – Hazardous Substances
800 West Wyoming Avenue
Lockland, Ohio
SME Project Number: 066744.00.004.002

Dear Mr. Krings:

SME prepared this Remedial Action Plan (RAP) for the referenced site using funds from the Village of Lockland's United States Environmental Protection Agency (USEPA) Brownfields Assessment Grant. Based on the findings of our assessment of the referenced property, the soil excavation, disposal, and backfilling discussed in the RAP should be completed prior to the construction of new structures or occupation of the Property.

If you or other stakeholders have any questions concerning this letter or the RAP, feel free to call me (513) 898-9430.

Very truly yours,

SME

Keith Egan, Ohio CP #259
Senior Consultant

Distribution: Mr. Christopher Choi, EPA

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FIGURES

ATTACHMENT A

1.0 INTRODUCTION

The Village of Lockland has received a United States Environmental Protection Agency (USEPA) Brownfields Assessment Grant for hazardous substances. The Village of Lockland intends to support the redevelopment of the brownfield property located at 800 West Wyoming Avenue, Lockland, Hamilton County, Ohio (the Property).

Environmental conditions at the Property are creating an impediment to Property re-use. Soil, groundwater, and soil gas on the Property have been impacted by volatile organic compounds (VOCs) and polynuclear aromatic hydrocarbons (PAHs). The extent of impact has been determined during a Phase II Environmental Site Assessment.

SME, environmental consultant for the Village of Lockland, prepared this Remedial Action Plan (RAP) to outline the tasks associated with removing the impact which exceeds Voluntary Action Program (VAP) commercial/industrials standards. The primary intent of the RAP is to mitigate the potential exposure to VOC vapors and eliminate the risk from direct contact with PAHs. This RAP includes a brief overview of the Property's history and prior environmental activities, a description of the proposed scope of work, a proposed budget, and an anticipated schedule.

2.0 PROPERTY HISTORY AND ENVIRONMENTAL CONDITIONS

Based on the October 2014 Phase I Environmental Site Assessment (Phase I ESA) we prepared, it appears that the Property was originally developed as early as 1886 with a grocery store. Between at least the 1930s until the 1970s or 1980s, the Property was developed with an automobile service and filling station, complete with underground storage tanks (USTs) and hoists. The buildings have since been demolished; the USTs were removed in 2012. The Property currently consists of 0.298 acres of asphalt-, concrete-, and grass-covered land. The foundations of former buildings are present in the center and northeast portions of the Property. The surrounding area is a combination of residential and commercial properties. Property features developed from the observations, field notes, photographs, and/or historical information collected during conduct of the Phase I ESA and are shown on Figure 1.

Our knowledge of suspected/potential environmental impacts on the Property was developed through our Phase I Environmental Site Investigation (ESA). We identified the potential for environmental impact associated with the following recognized environmental conditions (RECs) in connection with the Property:

- The potential for undetected and/or unreported releases of hazardous substances associated with
    - the historical automobile service and filling station, in operation between at least the 1930s until the 1970s or 1980s;
    - the former hydraulic hoist located near the eastern edge of the existing concrete building pad; and
    - the potential for additional USTs on the Property.
- The known benzene impact, as determined during the removal of 3 USTs and subsequent soil borings and monitoring well installations conducted as part of a Bureau of Underground Storage Tank Regulations (BUSTR) investigation[1].
- The potential for environmental impact from undetected and/or unreported migration of hazardous substances and/or petroleum products on to the Property from
    - the east-adjoining historical paint, furniture assembly and repair, and automobile sales and repair operations, in operation at various times between at least the 1950s and the 1990s;
    - the south-adjoining site in operation as a furniture repair and upholstering center between at least 1950 and 1981;
    - the southeast-adjoining historical gas station and auto sales and service station, in operation between at least 1937 and 1981, including releases from two USTs that may still be present;
    - the west-adjoining historical auto sales and service station, in operation between at least 1950 and 1981;
    - the historical coal storage yard, junk yard, used auto parts store, and auto service center in operation at various times between at least 1896 and 2003, and located approximately 250 feet to the southwest; and
    - the filling station with as many as five gas tanks that was present between at least 1937 and 1981 on the site located approximately 200 feet to the west.

[1] SME conducted this investigation using funds from a USEPA Brownfield Assessment grant obtained by the Port of Greater Cincinnati Development Authority. After completing the investigation, SME urged the Village of Lockland to engage an environmental attorney to challenge BUSTR's regulatory authority over the Property since the USTs had been removed prior to the promulgation of the UST regulations. The attorney succeeded and the release from the USTs is not regulated under BUSTR.

A series of assessments were conducted on the Property between December 2014 and April 2015 as part of another SME Phase II ESA to evaluate all of the RECs and not just the release from the USTs. Figure 1 also shows the locations of soil, groundwater, and soil gas samples collected during our Phase II ESA. The assessment activities were designed to characterize current Property conditions to support identification of environmental liability in conjunction with the potential redevelopment of the Property. The Property assessment goals included the following objectives:

- Evaluate if chemicals of concern (COCs) associated with the RECs identified in the Phase I ESA are present in the soil, groundwater, or soil gas at levels that may present a threat to human health; and
- If COCs present, evaluate the extent of impact and whether current environmental conditions warrant remediation.

These Property assessment goals were achieved through the following:

- Conducted limited subsurface activities to assess potential environmental impacts from both on-site and off-site sources, as identified during the Phase I ESA;
- Determined if the regulated constituents are present at concentrations greater than Ohio VAP commercial/industrial standards; and
- Generated sufficient data to determine if the future use could require remediation of soil, groundwater, or soil gas to meet risk-based and regulatory goals.

With the exception of two PAHs (benzo(a)pyrene and dibenzo(a,h)anthracene) in the shallow soil at SB2 and the SB2 delineation locations (area shown on Figure 1), and ethylbenzene and naphthalene in the deep soil at SB7 (near the former USTs), the concentrations were less than their respective VAP commercial/industrial direct contact standards.

Benzene, chromium, and lead concentrations exceeded the unrestricted potable use standard (UPUS) in the groundwater samples. We believe the presence of lead and chromium in the wells is a false positive due to using pre-pack wells. The Property is supplied with potable water from a municipal supply, and the planned future use will not use groundwater; therefore the UPUS exceedance does not pose a concern for the Property. A groundwater use restriction will be implemented that will ensure future receptors will not use the groundwater for potable purposes.

The soil gas screening levels were calculated by dividing the Generic Indoor Air Standard by an attenuation factor of 0.1 as specified in EPA guidance document EPA530-D-02-004 and Ohio guidance document Sample Collection and Evaluation of Vapor Intrusion to Indoor Air, dated May 2010. Ethylbenzene and hexane at SG1 (east of the former USTs) exceeded the soil gas to indoor air attenuation factor adjusted Indoor Air Standard. These chemicals were not detected in groundwater and the source of the vapors was attributed to impacted soil.

SME concluded that of the chemicals of concern measured in soil, soil gas, and groundwater, only exceedances the soil needed to be remediated to protect human health; the groundwater use restriction would protect human health by preventing consumption of groundwater. This Remedial Action Plan addresses the dermal contact and vapor intrusion risks.

3.0 MITIGATION

Approaches to mitigate the environmental issues detailed in Section 2 include:

- Source removal of soil impacted at levels exceeding the dermal contact standards and causing the vapor intrusion exceedances;
- Placement of a dermal contact barrier overlying the PAH impact area and an active sub-slab depressurization (ASSD) system in the area with vapor intrusion exceedances; or
- Placement of a dermal contact barrier overlying the PAH impact area and a passive barrier coating (e.g. Retro-Coat™ and Geo-Seal) that is applied to the surface of concrete in the area with vapor intrusion exceedances.

Due to the unknown future use of the Property and the potential costs associated with the ASSD and passive barrier coatings, SME recommends the source removal approach. Source removal consists of excavating the impacted materials, sampling to confirm the impacted soil have been removed, disposal of impacted materials, and backfilling of the resulting excavation. Details on the procedures are documented in the following subsections.

3.1 SOIL EXCAVATION AND DISPOSAL

The areas to be excavated are shown on Figure 2. A mechanical excavator will be used to excavate soil to a depth of 2.5 feet in Area 1 (the PAH impacted soil) and to a depth of 12 feet in Area 2 (the source of the vapor intrusion exceedances). Excavated materials will be direct-loaded and transported for disposal. Existing analytical data supports the conclusion that all impacted soil is considered non-hazardous and therefore can be disposed of in a licensed type II landfill or a petroleum disposal facility such as the Petro Cell in Washington Courthouse. Sloping will be completed as needed for stability.

We anticipate the removal of approximately 180 cubic yards in Area 1 and 290 cubic yards in Area 2, resulting in a total removal volume of 470 cubic yards, or the approximate equivalent of 800 tons. The final excavation depths and boundaries will be dependent on verification of soil remediation (VSR) analytical results.

3.2 SOIL SAMPLING

Upon reaching the anticipated extent of the excavation, VSR samples should be collected and analyzed for ethylbenzene and hexane in Area 2. Analytical results must be less than the subsurface soil to indoor air standards derived in Attachment A. For hexane, the threshold value is 9.2 mg/kg and for ethylbenzene the threshold value is 3,770 mg/kg. However, the ethylbenzene soil saturation value is 480 mg/kg and Ohio does not allow saturation levels of chemicals to be present in soils. Therefore the soil cleanup levels are as follows:

- Hexane – 9.2 mg/kg
- Ethylbenzene – 480 mg/kg

If analytical results exceed the acceptable standards, additional soil should be excavated until compliance values are achieved.

Soil samples should be collected using a mechanical excavator, eliminating the need for entry into the excavation. If entry is required, excavation walls should be sloped to conform with OSHA standards for safe excavation entry. Samples should be collected with a minimum frequency of one sample per 100 square feet and biased towards areas of known impact.

3.3 BACKFILLING

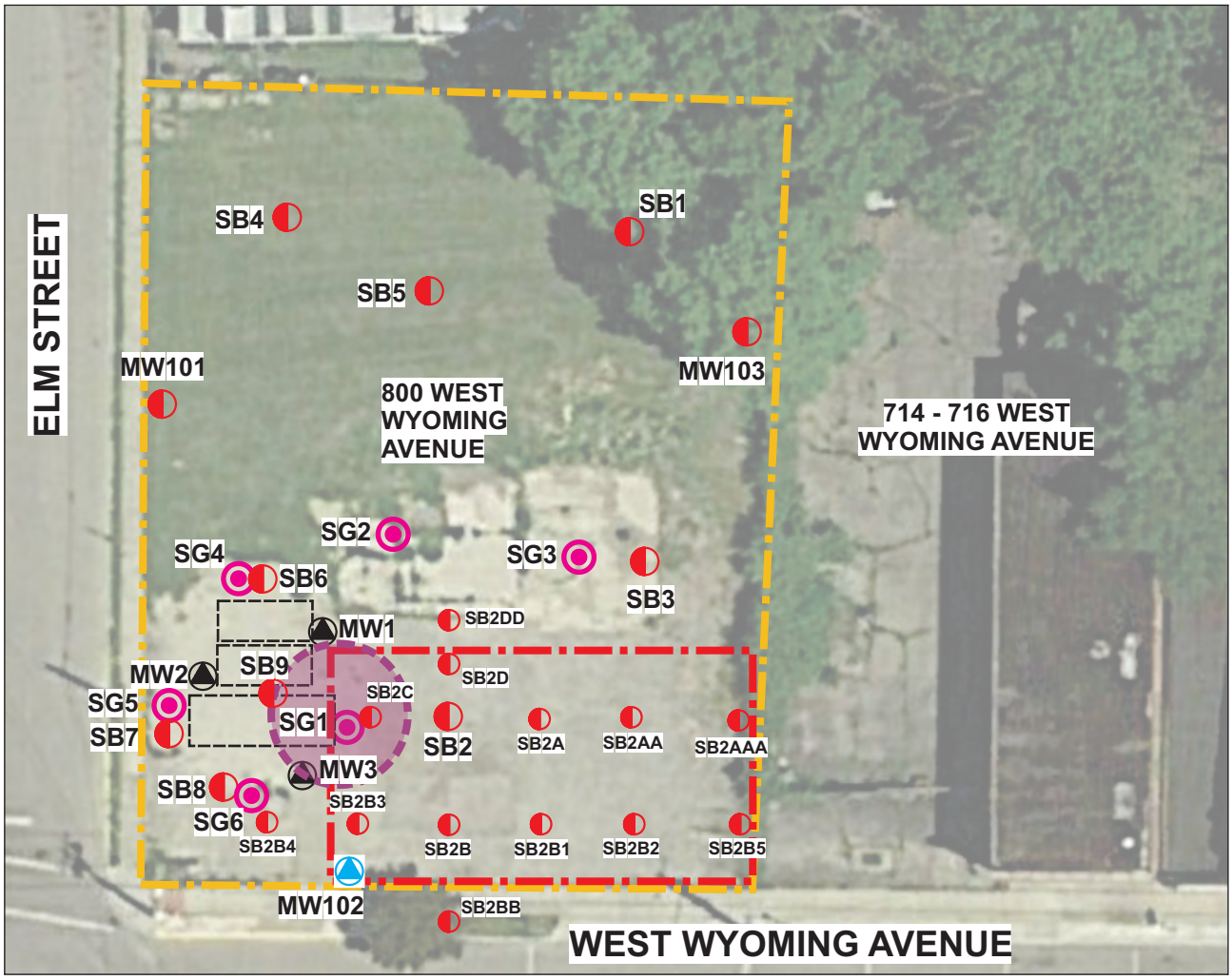
Following the removal of the impacted soil, the resulting excavations will be backfilled with clean sand fill and capped with one foot of clean clay fill. The sand fill should be compacted in controlled, 1 foot to 1.5 foot lifts, using a hoe pack. The clay fill should be compacted in six inch lifts to a modified proctor of 95% using a hoe pack. Upon completion of backfilling, the ground surface in the excavation areas should be rough-graded.

The size of the area requiring backfilling, compaction and rough-grading will be dependent upon the amount of impacted soil removed. We estimate approximately 470 cubic yards of clean sand and clay fill will be required to backfill.

4.0 ESTIMATED BUDGET

In total, approximately 470 cubic yards (180 cubic yards in the PAH impacted area and 290 cubic yards in the vapor intrusion source area), the approximate equivalent of 800 tons, of impacted soil would need to be excavated to remove the PAH impacted soil and the vapor intrusion source area. The estimated cost to excavate, transport, and dispose of 800 tons of soil, and backfill the area would be approximately $45,000. The estimated cost to oversee the remedial work and analyze samples to confirm the success of the remediation is $5,000.

FIGURES



LEGEND

- APPROXIMATE PROPERTY BOUNDARY
- SOIL BORING LOCATION
- TEMPORARY MONITORING WELL LOCATION
- SOIL GAS SAMPLE LOCATION
- EXISTING MONITORING WELL
- FORMER UST LOCATION
- AREA EXCEEDING COMMERCIAL/INDUSTRIAL DIRECT CONTACT STANDARD
- AREA EXCEEDING COMMERCIAL/INDUSTRIAL VAPOR INTRUSION STANDARD

NOTE:
DRAWING INFORMATION TAKEN FROM GOOGLE EARTH PRO – 2014 AERIAL PHOTO AND PROPERTY RECONNAISSANCE.

NORTH

0 30 60

GRAPHIC SCALE: 1" = 30'

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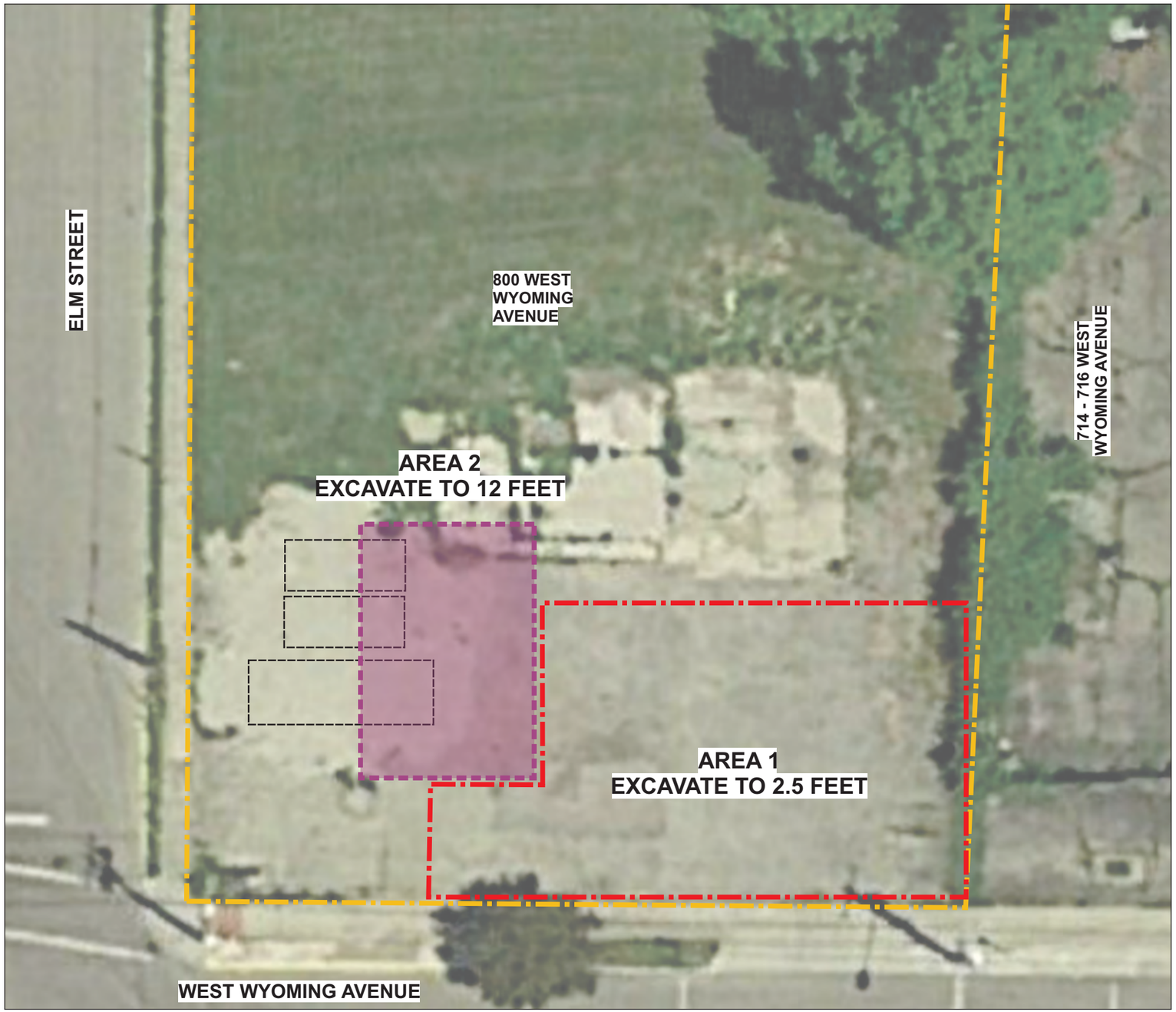
Date	09-29-2014
Drawn By	JWH
Designed By	JWH
Scale	1' = 30'
Project	066744.00.003.009

PROPERTY FEATURES AND SAMPLE LOCATION DIAGRAM
800 WEST WYOMING AVENUE
LOCKLAND, OHIO

No.	Revision Date

Figure No. 1



LEGEND

- APPROXIMATE PROPERTY BOUNDARY
- FORMER UST LOCATION
- **AREA 1 -** EXCAVATION TO DEPTH OF 2.5 FEET BELOW GRADE
- **AREA 2 -** EXCAVATION TO DEPTH OF 12 FEET BELOW GRADE

NOTE:
DRAWING INFORMATION TAKEN FROM GOOGLE EARTH PRO – 2014 AERIAL PHOTO AND PROPERTY RECONNAISSANCE.

NORTH

0 15 30

GRAPHIC SCALE: 1" = 15'

No.	Revision Date

EXCAVATION LOCATION DIAGRAM
800 WEST WYOMING AVENUE
LOCKLAND, OHIO

Date	09-29-2014
Drawn By	JWH
Designed By	JWH
Scale	1' = 15'
Project	066744.00.003.009

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Figure No. 2

ATTACHMENT A
SOIL TO INDOOR AIR CALCULATED STANDARDS

2005 BUSTR Tier 2 Soil To Indoor Air Pathway Evaluation

Version 2.0 (March 2005)

	Chemical Name	D^{air} cm^2/s	D^{wat} cm^2/s	H Dimensionless	K_{oc} cm^3/g	SF_i 1/(mg/kg-day)	RfD_i mg/kg-day
Chemical of Concern							
Ethylbenzene							

Use only if "other" is slected as Chemical of Concern

more

Receptor

Non-Residential

Soil Type

Soil Class 2

Depth of Source (feet)

10

Tier 1 default = 12

Building

Non-Residential Structure

Site Name (Title 1)

Site Name

Left Page Footer 1

Right Page Footer 1 (Release Number)

Site Address (Title 2)

800 West Wyoming

Left Page Footer 2

Right Page Footer 2

Filename

Print Tables

Reset Tables

2005 Subsurface Soil to Indoor Air
Site Name
800 West Wyoming

Table 1

Summary of Input Parameters
(Non-Residential Receptor / Soil Class 2 / Non-Residential Structure / Ethylbenzene)

Description	Source / Default	Symbol	Value	Units	Reference
Target Risk Levels					
Target Risk	Default	TR	1.0E-05	unitless	
Target hazard quotient	Default	THQ	1.0	unitless	
Exposure Parameters for Non-Residential					
Averaging Time for Carcinogens	Default	AT_c	70	yr	
Averaging Time for Non-Carcinogens	Default	AT_n	25	yr	
Body Weight	Default	BW	70	kg	
Exposure duration	Default	ED	25	yr	
Exposure frequency	Default	EF	250	d/yr	
Exposure time for indoor air	Default	ET	8	hr/d	
Daily indoor inhalation rate	Default	IR_{air}	0.833	m^3/hr	
Vadose Zone Hydraulic Parameters					
Depth to bottom of basement	Default	L_1	243.84	cm	
Depth to top of subsurface soil sources	10.0 Feet	L_2	304.8	cm	
Soil thickness between bottom of basement and source	L_2-L_1	L_s	60.96	cm	
Vadose Zone Soil Parameters for Soil Class 2					
Fraction organic carbon	Default	F_{oc}	0.0025	g oc/g soil	
Total soil porosity vadose zone	Default	Θ_T	0.43	cm^3/cm^3	
Volumetric water content in vadose zone	Default	Θ_{ws}	0.15	cm^3/cm^3	
Volumetric air content in vadose zone soils	Θ_T - Θ_{ws}	Θ_{as}	0.28	cm^3/cm^3	
Soil bulk density	Default	ρ_s	1.6	g/cm^3	
Indoor Volitilization / Building Parameters for Non-Residential Structure					
Enclosed-space air exchange rate	Default	ER	2.30E-04	1/s	
Ceiling Height	Default	L_B	487.68	cm	
Enclosed-space foundation or wall thickness	Default	Lcrack	15	cm	
Areal fraction of cracks in foundations/walls	Default	η	0.001	cm^2/cm^2	
Vol. air content in foundation/wall cracks	Default	Θ_{acrack}	0.25	cm^3/cm^3	
Vol. water content in foundation/wall cracks	Default	Θ_{wcrack}	0.19	cm^3/cm^3	
Chemical and Physical Properties for Ethylbenzene					
Diffusivity in air	Default	D^{air}	7.50E-02	cm^2/s	
Diffusivity in water	Default	D^{wat}	7.80E-06	cm^2/s	
Henry's Law Constant	Default	H	3.23E-01	unitless	
Soil / Water Partition Coefficient	Default	K_{oc}	2.04E+02	cm^3/g	
Partioning Coefficient	Koc x Foc	Ks	5.10E-01	cm^3/g	
Slope Factor Inhalation	Default	SF_i	ND	1/(mg/kg-day)	
Reference Dose Inhalation	Default	RfD_i	2.86E-01	mg/kg-day	

Tier 2 SSTL (mg/kg) **3.77E+03**

2005 Subsurface Soil to Indoor Air
Site Name
800 West Wyoming

Table 2

Derivation of Volatilization Factor
(Non-Residential Receptor / Soil Class 2 / Non-Residential Structure / Ethylbenzene)

$$VF = \frac{\dfrac{H\rho_s}{\theta_{WS} + k_s\rho_s + H\theta_{as}}\left[\dfrac{\dfrac{D_s^{eff}}{L_s}}{ER\ L_B}\right]}{1 + \left[\dfrac{\dfrac{D_s^{eff}}{L_s}}{ER\ L_B}\right] + \left[\dfrac{\dfrac{D_s^{eff}}{L_s}}{\left(\dfrac{D_{crack}^{eff}}{L_{crack}}\right)\div n}\right]} X\ 1000$$

$$D_s^{eff} = D^{air}\ \frac{\theta_{as}^{3.33}}{\theta_T^2} + D^{wat}\ \frac{1}{H}\ \frac{\theta_{ws}^{3.33}}{\theta_T^2}$$

$$D_{crack}^{eff} = D^{air}\ \frac{\theta_{acrack}^{3.33}}{\theta_T^2} + D^{wat}\ \frac{1}{H}\ \frac{\theta_{wcrack}^{3.33}}{\theta_T^2}$$

Parameter	Θ_T unitless	D^{air} cm^2/s	D^{wat} cm^2/s	H unitless	Θ_{as} unitless	Θ_{ws} unitless	Θ_{wcrack} unitless	Θ_{acrack} unitless	D eff crack cm^2/s	D eff s cm^2/s
Value	0.43	7.50E-02	7.80E-06	3.23E-01	0.28	0.15	0.19	0.25	4.01E-03	5.85E-03

Parameter	Ps g/cm^3	Ks cm^3/g	Ls cm	ER L/s	L_B cm	L_{crack} cm	η cm^2/cm^2	CF cm^3-kg/m^3-g	VF mg/m^3-air per mg/kg-soil
Value	1.6	5.10E-01	60.96	2.30E-04	487.68	15	0.001	1000	1.16E-03

2005 Subsurface Soil to Indoor Air
Site Name
800 West Wyoming

Table 3

Tier 2 SSTL Calculations
(Non-Residential Receptor / Soil Class 2 / Non-Residential Structure / Ethylbenzene)

SSTL for inhalation of vapors in air (carcinogenic effects)

$$SSTL_{air\text{-}c} = \frac{TR \times BW \times AT_c \times 365\frac{days}{year} \times 10^3\ \frac{ug}{mg}}{SF_i \times IR_{air} \times ET \times EF \times ED}$$ Commercial Equation

or

$$SSTL_{air\text{-}c} = \frac{TR \times AT_c \times 365\frac{days}{year} \times 10^3\ \frac{ug}{mg}}{SF_i \times ET \times EF \times \left[\frac{ED_{child} \times IR_{child}}{BW_{child}} + \frac{ED_{adult} \times IR_{adult}}{BW_{adult}}\right]}$$ Residential Equation

Receptors	TR dimensionless	BW kg	AT_c year	CF days/year	CF ug/mg	SF_i 1/mg/kg-day	IR_{air} m^3/hr	ET hours/day	EF days/year	ED years	$SSTL_{air\text{-}c}$ ug/m^3
Non-Residential	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

SSTL for inhalation of vapors in air (non-carcinogenic effects)

$$SSTL_{air\text{-}h} = \frac{THQ \times RfD \times BW \times AT_c \times 365\frac{days}{year} \times 10^3\ \frac{ug}{mg}}{IR_{air} \times ET \times EF \times ED}$$

Receptors	THQ dimensionless	BW kg	AT_{nc} year	CF days/year	CF ug/mg	RfD_i mg/kg-day	IR_{air} m^3/hr	ET hours/day	EF days/year	ED years	$SSTL_{air\text{-}h}$ ug/m^3
Non-Residential	1	70	25	365	1.00E+03	2.86E-01	8.33E-01	8	250	25	4.39E+03

SSTL for inhalation of indoor vapors from subsurface soils (carcinogenic effects)

$$SSTL_{soil\text{-}air\text{-}c} = \frac{SSTL_{air\text{-}c}}{VF} \times 10^{-3}\ \frac{mg}{ug}$$

Receptors	VF mg/m3-air per mg/kg-soil	$SSTL_{air\text{-}c}$ ug/m^3	CF mg/ug	$SSTL_{soil\text{-}air\text{-}c}$ mg/kg
Non-Residential	NA	NA	NA	NA

SSTL for inhalation of indoor vapors from subsurface soils (non-carcinogenic effects)

$$SSTL_{soil\text{-}air\text{-}h} = \frac{SSTL_{air\text{-}h}}{VF} \times 10^{-3}\ \frac{mg}{ug}$$

Receptors	VF mg/m3-air per mg/kg-soil	$SSTL_{air\text{-}h}$ ug/m^3	CF mg/ug	$SSTL_{soil\text{-}air\text{-}h}$ mg/kg
Non-Residential	1.16E-03	4.39E+03	1.00E-03	3.77E+03

Applicable Tier 2 SSTL (mg/kg) **3.77E+03**

2005 BUSTR Tier 2 Soil To Indoor Air Pathway Evaluation

Version 2.0 (March 2005)

Chemical of Concern	Chemical Name	D^{air} cm^2/s	D^{wat} cm^2/s	H Dimensionless	K_{oc} cm^3/g	SF_i 1/(mg/kg-day)	RfD_i mg/kg-day
Other	Hexane	7.31E-02	8.17E-06	7.36E+00	1.32E+02	ND	6.00E-02

Use only if "other" is slected as Chemical of Concern

more

Receptor

Non-Residential

Soil Type

Soil Class 2

Depth of Source (feet)

10

Tier 1 default = 12

Building

Non-Residential Structure

Site Name (Title 1)

Site Name

Left Page Footer 1

Right Page Footer 1 (Release Number)

Site Address (Title 2)

800 West Wyoming

Left Page Footer 2

Right Page Footer 2

Filename

Print Tables

Reset Tables

2005 Subsurface Soil to Indoor Air
Site Name
800 West Wyoming

Table 1

Summary of Input Parameters
(Non-Residential Receptor / Soil Class 2 / Non-Residential Structure / Other)

Description	Source / Default	Symbol	Value	Units	Reference
Target Risk Levels					
Target Risk	Default	TR	1.0E-05	unitless	
Target hazard quotient	Default	THQ	1.0	unitless	
Exposure Parameters for Non-Residential					
Averaging Time for Carcinogens	Default	AT_c	70	yr	
Averaging Time for Non-Carcinogens	Default	AT_n	25	yr	
Body Weight	Default	BW	70	kg	
Exposure duration	Default	ED	25	yr	
Exposure frequency	Default	EF	250	d/yr	
Exposure time for indoor air	Default	ET	8	hr/d	
Daily indoor inhalation rate	Default	IR_{air}	0.833	m^3/hr	
Vadose Zone Hydraulic Parameters					
Depth to bottom of basement	Default	L_1	243.84	cm	
Depth to top of subsurface soil sources	10.0 Feet	L_2	304.8	cm	
Soil thickness between bottom of basement and source	L_2-L_1	L_s	60.96	cm	
Vadose Zone Soil Parameters for Soil Class 2					
Fraction organic carbon	Default	F_{oc}	0.0025	g oc/g soil	
Total soil porosity vadose zone	Default	Θ_T	0.43	cm^3/cm^3	
Volumetric water content in vadose zone	Default	Θ_{ws}	0.15	cm^3/cm^3	
Volumetric air content in vadose zone soils	Θ_T - Θ_{ws}	Θ_{as}	0.28	cm^3/cm^3	
Soil bulk density	Default	ρ_s	1.6	g/cm^3	
Indoor Volitilization / Building Parameters for Non-Residential Structure					
Enclosed-space air exchange rate	Default	ER	2.30E-04	1/s	
Ceiling Height	Default	L_B	487.68	cm	
Enclosed-space foundation or wall thickness	Default	Lcrack	15	cm	
Areal fraction of cracks in foundations/walls	Default	η	0.001	cm^2/cm^2	
Vol. air content in foundation/wall cracks	Default	Θ_{acrack}	0.25	cm^3/cm^3	
Vol. water content in foundation/wall cracks	Default	Θ_{wcrack}	0.19	cm^3/cm^3	
Chemical and Physical Properties for Other					
Diffusivity in air	Default	D^{air}	7.31E-02	cm^2/s	
Diffusivity in water	Default	D^{wat}	8.17E-06	cm^2/s	
Henry's Law Constant	Default	H	7.36E+00	unitless	
Soil / Water Partition Coefficient	Default	K_{oc}	1.32E+02	cm^3/g	
Partioning Coefficient	Koc x Foc	Ks	3.30E-01	cm^3/g	
Slope Factor Inhalation	Default	SF_i	ND	1/(mg/kg-day)	
Reference Dose Inhalation	Default	RfD_i	6.00E-02	mg/kg-day	

Tier 2 SSTL (mg/kg) **9.24E+01**

2005 Subsurface Soil to Indoor Air
Site Name
800 West Wyoming

Table 2

Derivation of Volatilization Factor
(Non-Residential Receptor / Soil Class 2 / Non-Residential Structure / Other)

$$VF = \frac{\dfrac{H\rho_s}{\theta_{WS} + k_s\rho_s + H\theta_{as}}\left[\dfrac{\dfrac{D_s^{eff}}{L_s}}{ER\ L_B}\right]}{1 + \left[\dfrac{\dfrac{D_s^{eff}}{L_s}}{ER\ L_B}\right] + \left[\dfrac{\dfrac{D_s^{eff}}{L_s}}{\left(\dfrac{D_{crack}^{eff}}{L_{crack}}\right)\eta}\right]} X\ 1000$$

$$D_s^{eff} = D^{air}\ \frac{\theta_{as}^{3.33}}{\theta_T^2} + D^{wat}\ \frac{1}{H}\ \frac{\theta_{ws}^{3.33}}{\theta_T^2}$$

$$D_{crack}^{eff} = D^{air}\ \frac{\theta_{acrack}^{3.33}}{\theta_T^2} + D^{wat}\ \frac{1}{H}\ \frac{\theta_{wcrack}^{3.33}}{\theta_T^2}$$

Parameter	Θ_T unitless	D^{air} cm^2/s	D^{wat} cm^2/s	H unitless	Θ_{as} unitless	Θ_{ws} unitless	Θ_{wcrack} unitless	Θ_{acrack} unitless	D eff crack cm^2/s	D eff s cm^2/s
Value	0.43	7.31E-02	8.17E-06	7.36E+00	0.28	0.15	0.19	0.25	3.91E-03	5.70E-03

Parameter	Ps g/cm^3	Ks cm^3/g	Ls cm	ER L/s	L_B cm	L_{crack} cm	η cm^2/cm^2	CF cm^3-kg/m^3-g	VF mg/m^3-air per mg/kg-soil
Value	1.6	3.30E-01	60.96	2.30E-04	487.68	15	0.001	1000	9.96E-03

2005 Subsurface Soil to Indoor Air
Site Name
800 West Wyoming

Table 3

Tier 2 SSTL Calculations
(Non-Residential Receptor / Soil Class 2 / Non-Residential Structure / Other)

SSTL for inhalation of vapors in air (carcinogenic effects)

$$SSTL_{air\text{-}c} = \frac{TR \times BW \times AT_c \times 365\frac{days}{year} \times 10^3\ \frac{ug}{mg}}{SF_i \times IR_{air} \times ET \times EF \times ED}$$ Commercial Equation

or

$$SSTL_{air\text{-}c} = \frac{TR \times AT_c \times 365\frac{days}{year} \times 10^3\ \frac{ug}{mg}}{SF_i \times ET \times EF \times \left[\frac{ED_{child} \times IR_{child}}{BW_{child}} + \frac{ED_{adult} \times IR_{adult}}{BW_{adult}}\right]}$$ Residential Equation

Receptors	TR dimensionless	BW kg	AT_c year	CF days/year	CF ug/mg	SF_i 1/mg/kg-day	IR_{air} m^3/hr	ET hours/day	EF days/year	ED years	$SSTL_{air\text{-}c}$ ug/m^3
Non-Residential	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

SSTL for inhalation of vapors in air (non-carcinogenic effects)

$$SSTL_{air\text{-}h} = \frac{THQ \times RfD \times BW \times AT_c \times 365\frac{days}{year} \times 10^3\ \frac{ug}{mg}}{IR_{air} \times ET \times EF \times ED}$$

Receptors	THQ dimensionless	BW kg	AT_{nc} year	CF days/year	CF ug/mg	RfD_i mg/kg-day	IR_{air} m^3/hr	ET hours/day	EF days/year	ED years	$SSTL_{air\text{-}h}$ ug/m^3
Non-Residential	1	70	25	365	1.00E+03	6.00E-02	8.33E-01	8	250	25	9.20E+02

SSTL for inhalation of indoor vapors from subsurface soils (carcinogenic effects)

$$SSTL_{soil\text{-}air\text{-}c} = \frac{SSTL_{air\text{-}c}}{VF} \times 10^{-3}\ \frac{mg}{ug}$$

Receptors	VF mg/m3-air per mg/kg-soil	$SSTL_{air\text{-}c}$ ug/m^3	CF mg/ug	$SSTL_{soil\text{-}air\text{-}c}$ mg/kg
Non-Residential	NA	NA	NA	NA

SSTL for inhalation of indoor vapors from subsurface soils (non-carcinogenic effects)

$$SSTL_{soil\text{-}air\text{-}h} = \frac{SSTL_{air\text{-}h}}{VF} \times 10^{-3}\ \frac{mg}{ug}$$

Receptors	VF mg/m3-air per mg/kg-soil	$SSTL_{air\text{-}h}$ ug/m^3	CF mg/ug	$SSTL_{soil\text{-}air\text{-}h}$ mg/kg
Non-Residential	9.96E-03	9.20E+02	1.00E-03	9.24E+01

Applicable Tier 2 SSTL (mg/kg) **9.24E+01**

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